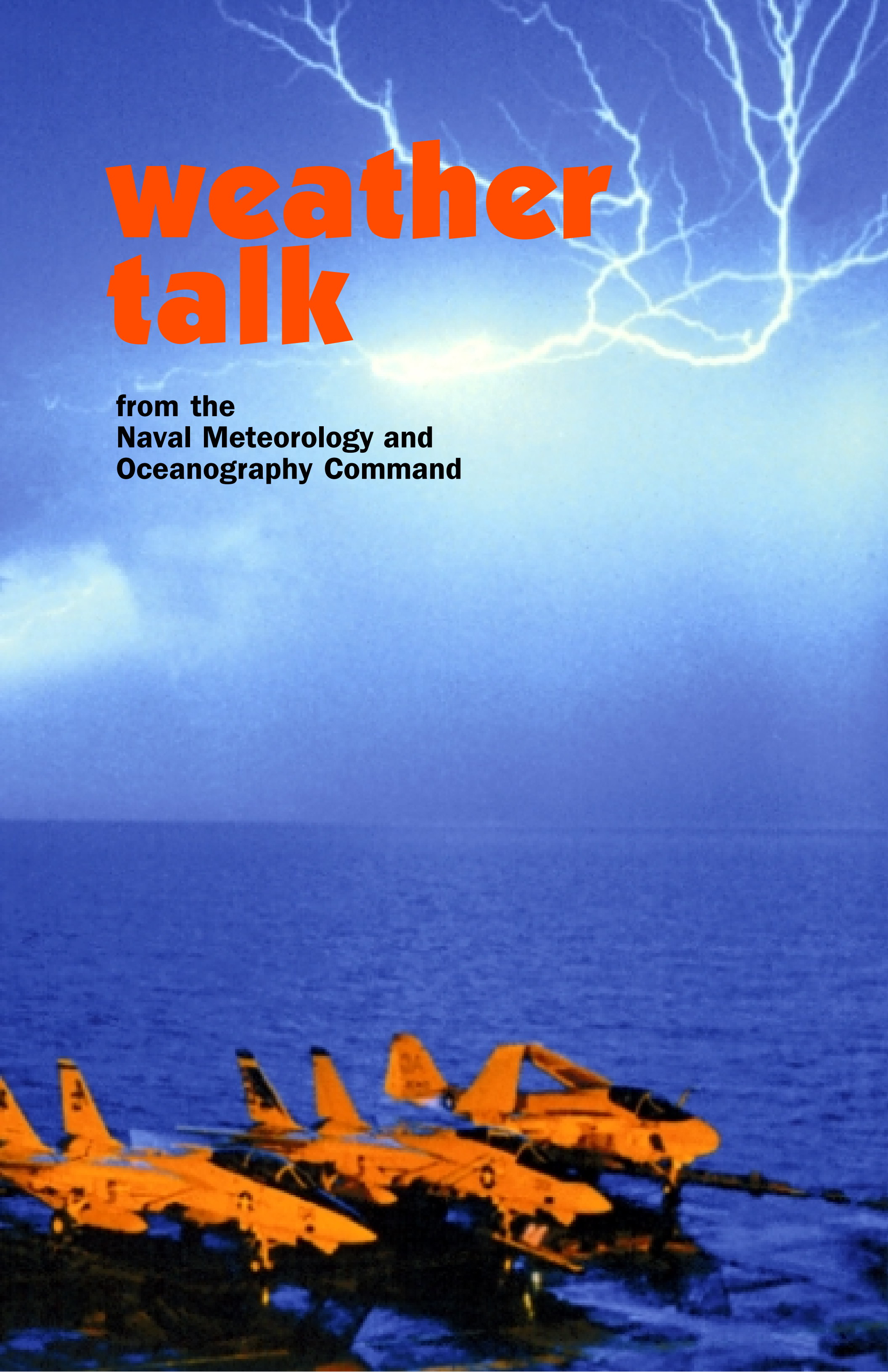
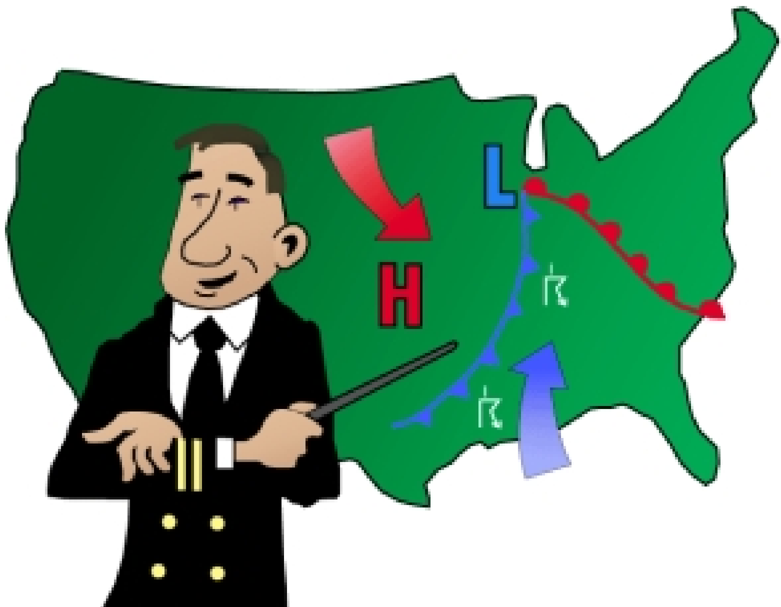
weather talk

from the Naval Meteorology and Oceanography Command



weather talk



Naval Meteorology
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INTRODUCTION

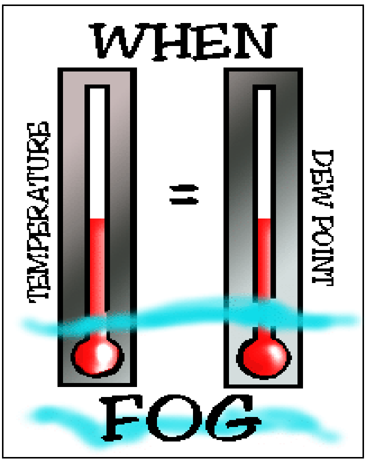
Weather has been defined as the state of the atmosphere, mainly with respect to its effects upon life and human activities. Our day to day efforts are affected either directly or indirectly by weather. Such basic responses as what to wear, allowances for extra commute time, flight delays due to weather, and even the types of work to be done are more often than not guided by what is happening in our atmosphere.

This is also true with the Navy. Weather is one of the first steps in planning any naval operation whether it be on, under or above the ocean, and is a major consideration in how the operation is executed. This information is provided to naval commanders by members of the Naval Meteorology and Oceanography Command from bases ashore and by teams of forecasters aboard ships. These men and women are highly trained in both meteorology and oceanography.

This pamphlet provides a brief overview of major weather elements and is presented in a non-mathematical way. It is our objective that the reader will have a better understanding of the basic mechanisms of weather and use it to their advantage and safety in planning and carrying out their own activities.

TEMPERATURE

Temperature is the degree of hotness or coldness as measured on a specified scale. The most commonly used temperature scales are: Fahrenheit, abbreviated F, and Celsius (also known as Centigrade) abbreviated C. Nine degrees on the Fahrenheit scale equals five degrees on the Celsius. The Celsius scale, from the metric system, is used extensively in Europe and elsewhere, particularly in scientific work.

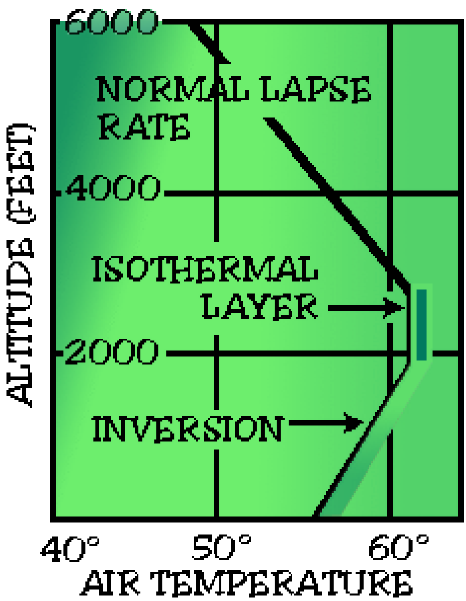


The observed air temperature depends upon geography, elevation above mean sea level (mountainous, plains, or coastal), prevailing winds, and proximity to large water areas such as oceans or significant lakes.

An example of topography's influence on temperature is the blocking action of mountain ranges on prevailing winds. Areas on the leeward sides of mountains are often protected from cold winter winds resulting in more moderate temperatures. In contrast, the summertime prevailing wind that blows inland across the chilly California Current brings cool temperatures to Pacific coastal regions of Washington, Oregon, and California.

The angle of the sun and distances from the equator are the principal factors responsible for global temperature distribution. There probably would be no variation in weather if the Earth were uniformly heated by the sun. The changing angles are responsible for seasonal changes of cold winters and warm to hot summers. Fortunately, the Earth in its rotation about the sun tilts at an angle of 23.5 degrees from the vertical. This results in uneven heating of the globe, causing low temperatures at high latitudes and high temperatures at the equator. Most of the cities in the Continental United States are in the mid latitudes. That is a region where the sun's rays intersect the Earth's surface at varying angles; high in the summer and low in the winter. Along and near the equator there is close to 12 hours of overhead sunlight each day. As a result there are no significant seasonal temperature changes, although there are distinct dry and rainy seasons in the tropics.

The decrease of temperature with altitude is defined as the lapse rate. The lapse rate from the surface to 60,000 feet averages about five degrees F. per thousand feet of altitude. Under certain meteorological conditions, however, temperature can increase with altitude in the very lowest layers of the atmosphere. Such a phenomenon is called an inversion.



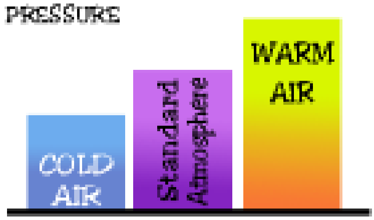
An inversion acts as a ceiling in the lower atmosphere that allows trapped pollution to become a witches brew of concentrated smog and health hazards, such as breathing difficulties and reduced visibility.

PRESSURE

We live at the bottom of an ocean of air composed of about four-fifths nitrogen and one-fifth oxygen. However, 99 percent of the Earth's atmosphere is contained in a thin 20 mile layer wrapped around the globe. Nearly three fourths of the atmosphere is found in the lowest 6 to 7 miles. Minute traces of the Earth's atmosphere have been detected outwards in space to about 70 miles.

Like most substances subjected to temperature change, the Earth's atmosphere expands and contracts. The atmosphere at the equator is heated by the overhead sun and contact with the heated surface. A characteristic of warm tropical air is that it is very buoyant, therefore, lighter in weight, which causes lower atmospheric pressure. In polar regions, the low angle of the sun delivers less energy to heat the earth's surface. As a result, overlying air is cold and dense, which results in higher atmospheric pressure.

THE EFFECT OF TEMPERATURE ON PRESSURE



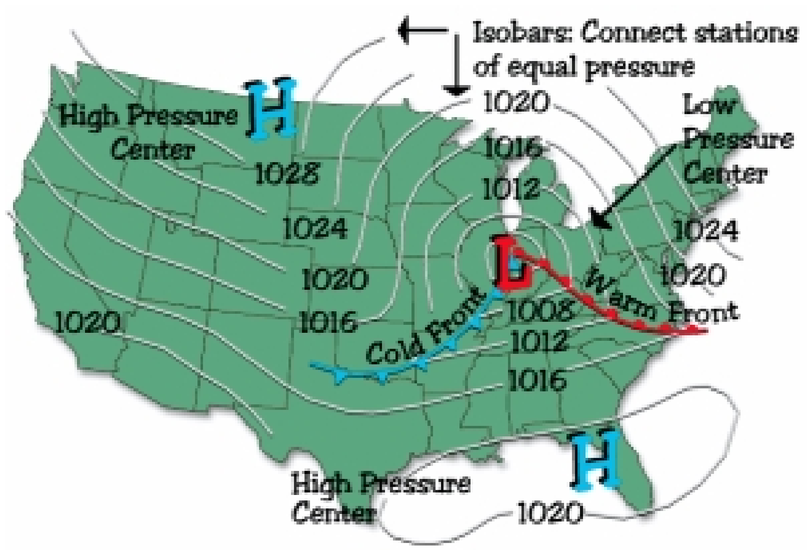
Three columns of air, each with different temperatures but with equal pressure at the top and the bottom illustrates how the decrease of pressure with height depends on temperature.

The atmosphere has tremendous weight. At sea level it weighs about 14.7 pounds per square inch, or about 20 tons on the average sized human. However, at an altitude of 70 miles the atmosphere weighs only 1/100,000 of the pressure at sea level.

Air is not a solid and cannot be weighed by conventional scales. Three centuries ago, Toricelli designed an instrument that could do the job. He measured pressure and converted it directly to weight.

His instrument, the mercurial barometer, consisted of a container of mercury into which he placed the open end of a glass tube, about a yard long, from which all air had been evacuated. Atmospheric pressure forced the mercury to rise in the tube and provided the means to gauge pressure. A column of mercury 1 inch in diameter and 30 inches high weighs as much as the entire column of atmosphere. Incidentally, mercury, the heaviest substance available that remains a liquid at ordinary temperatures, permits the barometer to be of a manageable size. Toricelli could have used water in his barometer, but at sea level it would have been 34 feet tall.

The atmospheric pressure observation is the principal weather element used in forecasting weather. Significant changes in pressure usually precede a change in weather patterns. Large numbers of observations, preferably global, are required to prepare a weather forecast. Pressure is reported in millibars, which is a more precise scale than inches of mercury. For example, 1013.2 millibars is equal to 29.92 inches of mercury at sea level. Because pressure varies with elevation, observations made by weather stations are mathematically reduced to sea level to establish a universal reference level. The lines on a weather map that connect weather stations of equal pressure are called isobars and outline significant areas of high and low pressure as shown in the illustration.



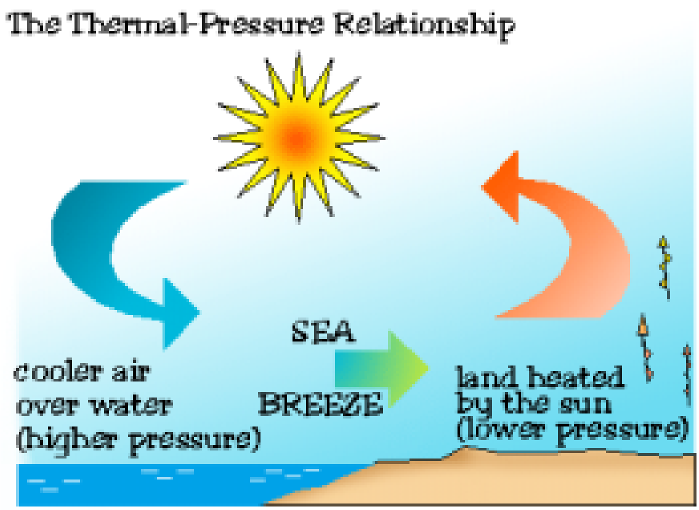
WIND

The first breath of wind starts with temperature. Notice on a summer day how heated air over a roadway shimmers as it rises. Open a freezer door and the ensuing condensation tracks the descent of cold air as it sinks to the floor. These different characteristics, rising warm air, sinking cold air and uneven heating of the Earth's surface are the principal mechanisms of atmospheric circulation (wind).

Wind strength is dependent upon the pressure field and is highest when pressure differences are the greatest. For example, a deepening low pressure system advancing across the mid latitudes in winter will usually generate strong winds in advance. The lower the pressure, the greater the likelihood of gale force winds. In the Northern Hemisphere winds blow inward and counterclockwise about a low pressure center. Winds associated with a high pressure system blow slightly outward from the center and in a clockwise fashion. A Dutch meteorologist named Buys

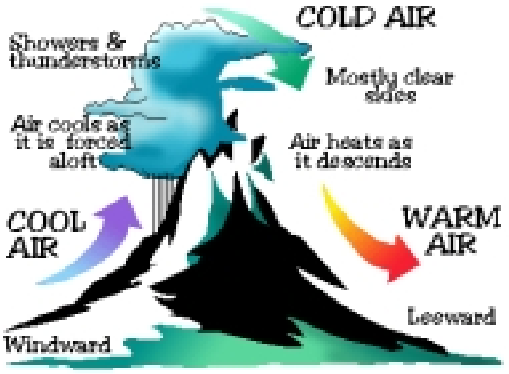
Ballot formulated a technique in 1857 to determine the location of pressure centers. With your back to the wind, pressure to your left is lower. In the Southern Hemisphere, the opposite is true.

The sea breeze is a classic example of the thermal-pressure relationship. Sea breezes occur when the land mass next to the water area heats up at a



much greater rate. This results in lower pressure over land, while pressure over water is higher. The sea breeze is the ensuing flow of air from high to low pressure. The strength of the sea breeze depends upon the difference between the temperature of the water and the adjacent coastal area. At night, the land cools more quickly than the water resulting in a reversal of wind flow from land to water.

The foehn wind is unlike the sea breeze in that it is observed only in mountain areas. Also, the mechanism for development is significantly different. A foehn



(the name originated in the Alps) occurs when a deep layer of prevailing wind is forced over a mountain range. As the wind descends to lower levels on the leeward side of the mountains, the air heats as it comes under greater atmospheric pressure creating strong gusty warm and dry winds. Foehn winds can raise temperatures as much as 50°F in just a matter of hours. These winds are known as "Chinooks" in the Rocky Mountains, and as a "Santa Ana" in Southern California.

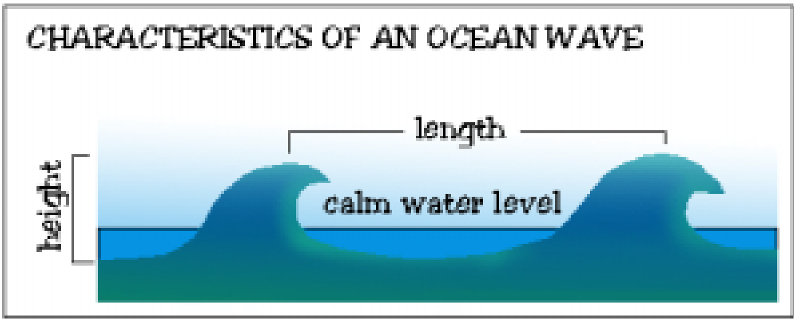
One of the most useful cold-weather tools to become available in recent years is the wind chill table. It considers both temperature and wind and is an excellent guide as to clothing needed for protection against uncomfortable weather. The wind chill table was originally developed in 1941 to assist U. S. personnel working in the extremely harsh Antarctic environment. A person out of doors loses much more body heat in a windy environment than in a calm atmosphere. As the wind increases, so

WIND CHILL TABLE

Wind Speed (mph)	Air Temperature (degrees F) 45	40	35	30	25	20
05	43	37	32	27	22	16
10	34	26	22	16	10	03
15	29	23	16	09	02	-05
20	26	19	12	04	-03	-10

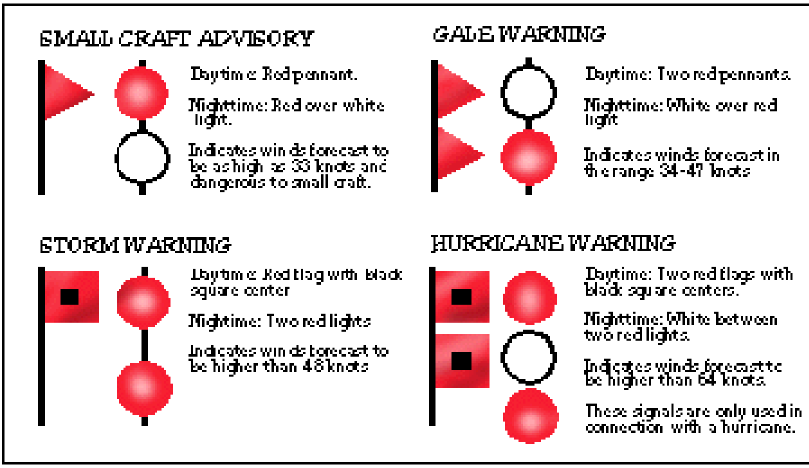
does the loss of body heat. The apparent temperature located in the wind chill table is a measure of how cold you might feel under certain temperature and wind conditions, regardless of the actual temperature reading. With a 20 mph wind, a temperature of 45°F. "feels like" a brisk 26°F.

Wind is also responsible for altering the water surface of oceans and lakes. Moving air in contact with water causes it to pile up in ridges, much like sand dunes. The height of the ridges – waves – depends upon the strength of the wind. The characteristics of a ocean wave as depicted in the graphic include its height and length. The height of a wave is the vertical distance between the crest and the trough; the length is the distance between successive crests or troughs. The time interval between passage of successive crests at a stationary point is called the wave period.



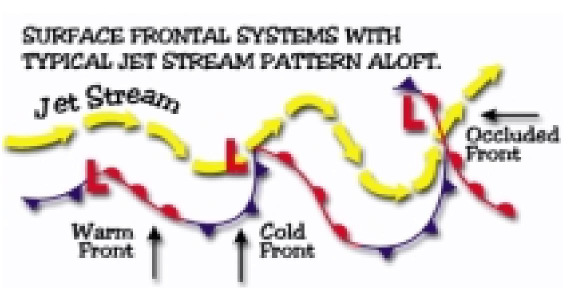
Small wavelets or ripples will appear as soon as a breeze of 2 mph flows across the water surface. Whitecaps begin to form on top of waves when winds reach about 15 mph. If the wind velocity increases to 50 mph for an extended period, it is possible for waves of 15 to 20 feet to develop. Waves whipped up by strong winds impart tremendous energy which can seriously damage beaches, piers, and breakwaters. A moderate storm at sea can send ashore as many as 600 waves an hour. The energy of each wave can be equal to a force of one ton slamming against every foot-length of beach obstruction.

Fishermen and recreational boaters are kept aware of local adverse wind conditions by visual indicators. Combinations of pennants, flags, and colored lights are used to warn of existing winds or of forecast increasing winds. The indicators are displayed by the Coast Guard, port authorities, and yacht clubs in prominent locations that ensure they can be easily seen by passing boaters. This method of



weather warning predates, but also augments, existing radio broadcasts that provide similar warnings to mariners. TV meteorologists in coastal areas also will note on their telecasts that warnings have been hoisted and note the area and time.

A discussion of winds would be incomplete without mentioning the jet stream, a narrow band of strong winds ranging from 50 to 250 knots. The jet stream is best described as a meandering river that circles the Earth in an undulating wave-like pattern at an altitude between 30,000 and 35,000 feet. A second, and occasionally a third, jet stream is often observed. The location of the jet stream over



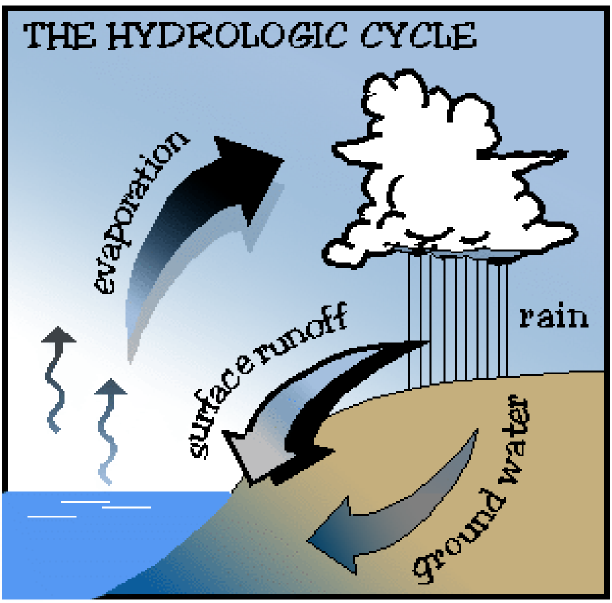
surface low pressure systems is used to determine the potential for intensification of the low.

The polar front jet stream is the predominant high altitude wind field that crosses the mid latitudes of North America. It is stronger in the winter months and drops further south as it moves from west to east. A second jet stream also influences the southern half of the nation. The subtropical jet stream travels globally between 20° and 30° north latitude and, while vigorous during passage over the U.S., it is strongest off the coast of Asia. The location of the jet stream is a major concern for commercial aviation. It is avoided when it is a head wind, and searched out when it provides a tail wind.

Another feature of the jet stream that is of interest to aviation and airline passengers is clear air turbulence (CAT). Most incidents of CAT occur on the north side of the jet stream axis, during winter when the jet stream is most intense. The severity of CAT has been likened to flying through a good sized cumulus cloud.

ATMOSPHERIC MOISTURE

Moisture is an absolute essential in our atmosphere. Without moisture there would be no clouds, precipitation, and probably no life! Fortunately there is a limited amount of moisture available in the atmosphere. It appears in three forms: gas (humidity), liquid (precipitation), and solid (ice and snow).

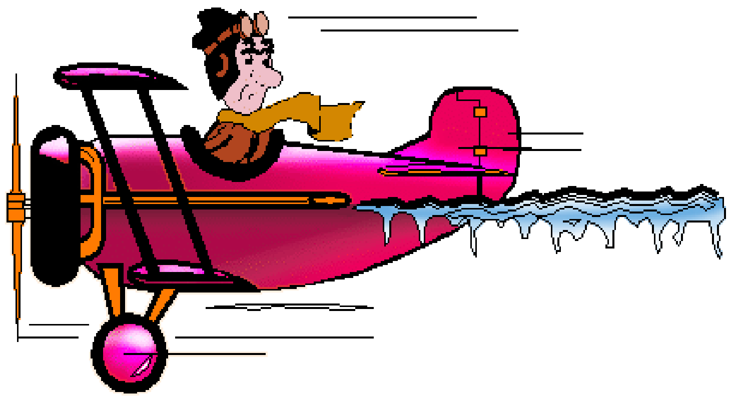


The Earth's reservoirs are the global oceans, glaciers, lakes, rivers, and streams. They provide the principal sources of water evaporation that escapes into the Earth's atmosphere to form clouds. Precipitation occurs in clouds when rapid condensation takes place. The fallen moisture returns to the oceans, rivers and streams as runoff and ground water where it evaporates again. This recycling of moisture is the hydrologic cycle.

The transition of atmospheric moisture from a gaseous state into a liquid state is condensation. Water vapor is the invisible source of clouds and rain and is also a form of heat transfer. Clouds develop when water vapor attaches itself to microscopic matter called nuclei. Atmospheric dust comes from many sources: fine dust swept up from farmlands, soot from fires, auto pollution, and minute particles of sea salt from distant turbulent oceans. The particles are tiny—less than one micron in diameter (a thousandth of a millimeter). They are so light that they can stay airborne for weeks at a time. The airborne nuclei form cloud droplets that develop into clouds. All nuclei, especially salts, have a natural affinity for moisture. This is an extremely important characteristic. When nuclei grow too heavy from absorbing other cloud droplets and can no longer remain suspended, they drop to earth as a form of precipitation. While individual raindrops

may not appear particularly large, they are giants compared to cloud droplets. One raindrop is equivalent to up to 10 million cloud droplets. The type of precipitation that falls depends upon the cloud type in which it originates. Not all clouds yield precipitation, in fact, most don't!. Especially contrails.

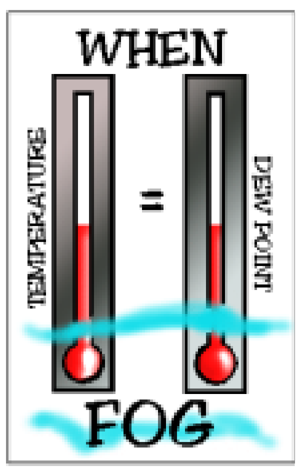
Those long slender ice crystal clouds seen forming in the wake of a high flying jet are caused by the



exhaust of moisture and heat from the aircraft's engines. The term "contrail" comes from combining condensation and trail.

For engine exhaust contrails to form, it is necessary for the aircraft to fly through very cold air, usually about minus forty degrees F. The exhausted moisture and heat saturate the air and condensation takes place almost immediately. The duration of the contrail depends upon the relative humidity of the surrounding air. If low, the contrail may not form or will disappear very quickly. In humid air, contrails can persist for many hours and have been known to trigger the formation of a thin overcast of cirrus clouds.

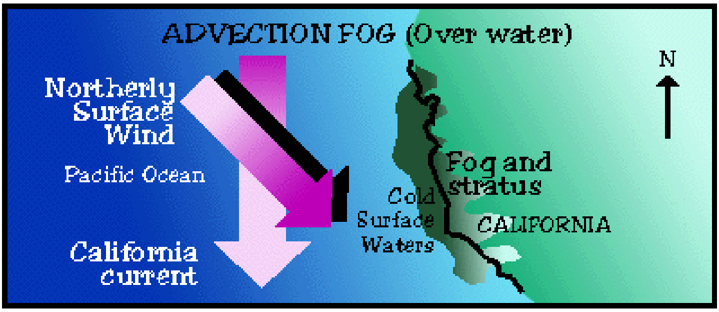
Water vapor is not only important in the development of clouds, contrails, precipitation and fog, but it is also important in our living environment. The amount of water vapor in a given air sample is measured in several different ways, either as dew point or relative humidity. The dew point is the temperature to which air must be cooled to become saturated. Dew point, when related to air temperature, indicates how close the air is to saturation. Relative humidity, on the other hand, relates the actual water vapor present to that which could be present. A relative humidity of 75% means that three fourths of the maximum amount of moisture the atmosphere can hold is present.

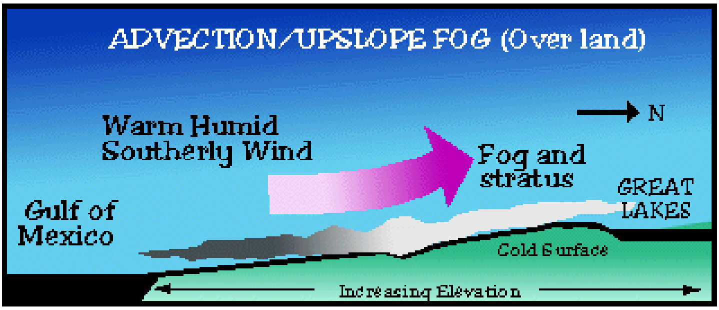


An example of the relationship between air temperature and dew point is fog, which is no more than a cloud whose base rests on the ground. Fog will usually form when the temperature and dew point are within a few degrees of one another. Two processes are involved in the formation of fog: (1) the air temperature is lowered to the dew point, or (2) the dew point is increased to the air temperature. In the first process, air temperature can be lowered as it crosses a colder surface such as chilly ocean waters or a large snow covered area. In the second process, atmospheric moisture usually increases when wind flow is from a maritime source such as the Gulf of Mexico or other ocean areas.

Of the two types of fog, radiation and advection, radiation fog is the least hazardous, more localized and usually less enduring. It occurs most often during cool autumn nights when the sky is clear and the Earth's surface cools rapidly. Although it may be present in the morning, it usually dissipates within hours after sunrise. This type of fog is also known as ground fog.

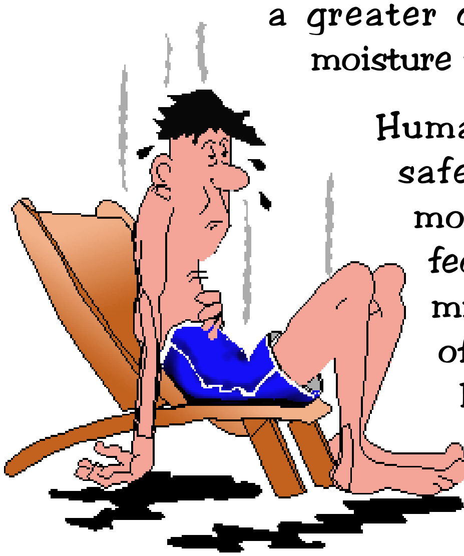
In contrast, advection fog can be dangerous and disruptive. It occurs most frequently during the winter months over the eastern half of the nation. It is not uncommon for surface visibility to be reduced to near zero conditions bringing highway and air traffic to a halt. Advection fog forms when moisture laden air from the Gulf of Mexico flows north-





ward and is gradually cooled as it moves over higher terrain. When the air temperature is reduced to the dew point, fog is formed. Similarly, advection fog in the coastal areas of California occurs when warm winds cross the chilly California Current, resulting in a persistent fog condition that can extend from San Francisco to San Diego.

The moisture holding capacity of air varies with temperature. If there is no change in the total moisture content during a 24 hour period, relative humidity will increase at night. The highest readings occur about sunrise which explains damp lawns and fogged car windows. Relative humidity decreases as the day heats up because warm air has a greater capacity to contain moisture than cold air.



Human efficiency and safety during summer months are directly affected by the level of humidity. The combination of excessive heat and humidity are recognized health hazards. Previously, older age groups were the most likely to succumb to extreme summer conditions. However, with today's emphasis on physical fitness, many younger people are becoming victims of hot weather. As shown in the table, when the air temperature reaches 90° F, and the relative humidity is 90%, the apparent temperature is equivalent to 122°F.

HEAT INDEX TABLE

Air Temperature	Relative Humidity (percent): 65	70	75	80	85	90	95	100
	APPARENT TEMPERATURE							
100	135	144						
95	119	124	130	138				
90	102	108	109	113	117	122		
85	91	93	95	97	99	102	105	108

Source: NOAA

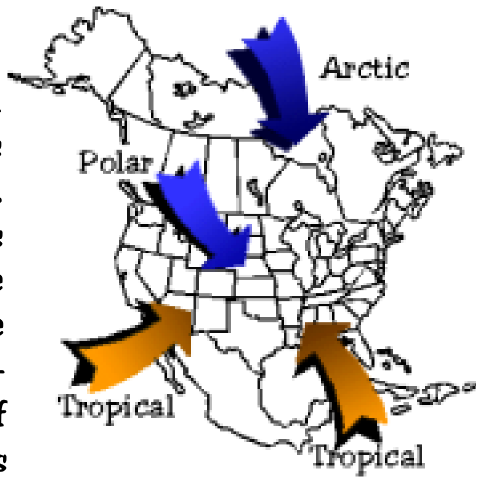
The old but true statement "it's not the heat, it's the humidity" summarizes the relationship between human moods and the environment. The higher the humidity, the slower the rate of evaporation of perspiration. As sweat becomes more profuse, we feel even more uncomfortable. Fortunately the depressed mood that sometimes accompanies high humidity serves as a safeguard against heat exhaustion, cramps and sunstrokes as we unconsciously slow our activities.

Hot weather sickness occurs when the body's mechanism for cooling is overtaxed – usually from the loss of too much water. The body uses sweating as a mean of maintaining a stable temperature, and on those days when the humidity is very high, perspiring is frequently ineffective. Early symptoms of heat exposure include irritability, pounding pulse, headaches, feeling hot and listless. If any of these symptoms occur, retreat to the shade and drink a cool liquid. Seek immediate medical assistance if nausea, dizziness, cramps, or a breathing problem occur.

AIR MASSES AND FRONTS

When a large body of air passes slowly over an extensive area with uniform characteristics of temperature and humidity, it takes on these attributes. The area from which the air mass derives its personality is its "source region."

Air mass source regions range from extensive snow covered polar areas to deserts to tropical oceans. The United States is not a favorable source region because of the relatively frequent passage of weather disturbances that disrupt any opportunity for an air mass to stagnate and take on the properties of the underlying region.



The principal air masses that influence the continental limits of the United States are the arctic, polar, and tropical. The arctic air mass brings the most frigid temperatures. An arctic outbreak that spreads southward across the Canadian border can bring record-breaking cold temperatures to the nation. Clear skies, extremely low humidity, and high atmospheric pressure prevail. The portions of the country most frequently affected by this air mass are the states between the Cascade and Sierra Nevada Mountains and New England. On occasion, even the Gulf Coast is touched by the icy finger of an arctic air mass. As much as two thirds of the nation can be affected by the bitter cold. Arctic air masses are responsible for bringing below zero weather to every state in the Union including Florida.

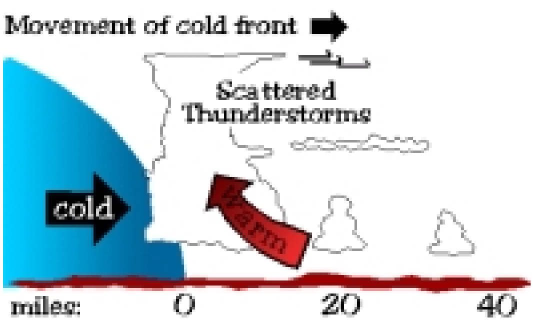
Polar air masses formed over Canada and the Gulf of Alaska are common winter-time intruders of the continental limits. They are similar in the crisp dry cold-air that accompanies it, but not as bitterly cold as the arctic air mass.

The Gulf Coast states and the eastern third of the country commonly experience the tropical air mass in the summer. At times during the winter months tropical air masses form between California and Hawaii and drift eastward to affect West Coast weather.

When an air mass moves from its source region, it meets an adjacent air mass with different properties. The zone between the differing air masses is a frontal zone or front where the contrast between temperature, humidity, and wind direction can be considerable.

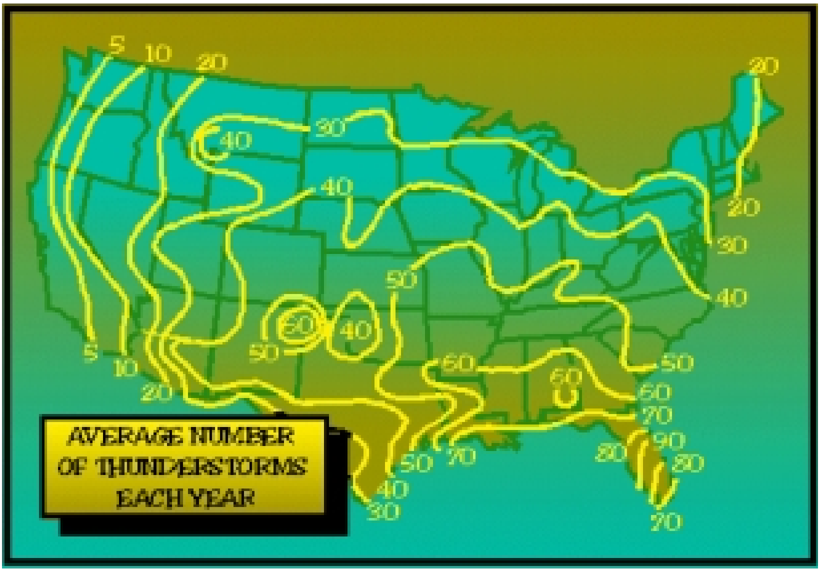
The cold front is the most commonly observed and has visited every state including Hawaii. Cold fronts are responsible for damaging weather – squalls, tornadoes, and strong winds – during the transitional months between winter and spring, and summer and fall.

Other fronts include the warm, occluded, and stationary. The warm front is most common during winter months. Warm front weather includes widespread fog, and continuous precipitation as it advances slowly northward toward Canada. When the leading edge of an air mass is not displacing the airmass ahead of it, the frontal zone or front is stationary. The occluded front occurs during the development of major low pressure systems and is more common in the northern half of the country. It forms when the faster moving cold front catches up with a warm front. Stationary front weather can have weather similar to both the warm and cold front. Clouds and precipitation are usually more extensive along an occluded front.



THUNDERSTORMS

Thunderstorms present one of Mother Nature's most spectacular displays of sight and sound. They



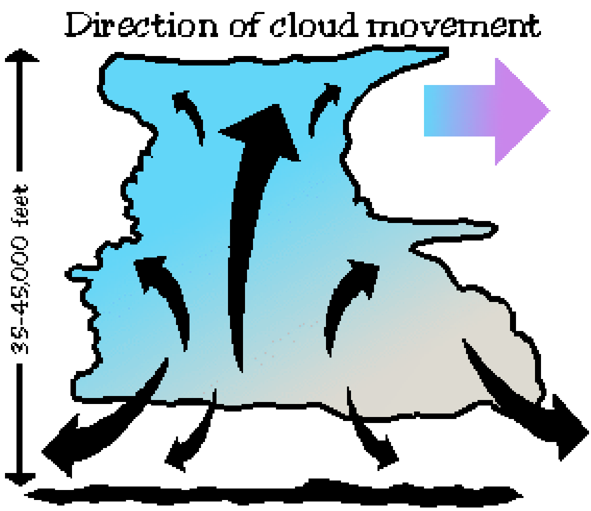
are also one of the more formidable weather hazards.

Thunderstorms can occur during any month of the year and at any time of day if the right meteorological conditions are present.

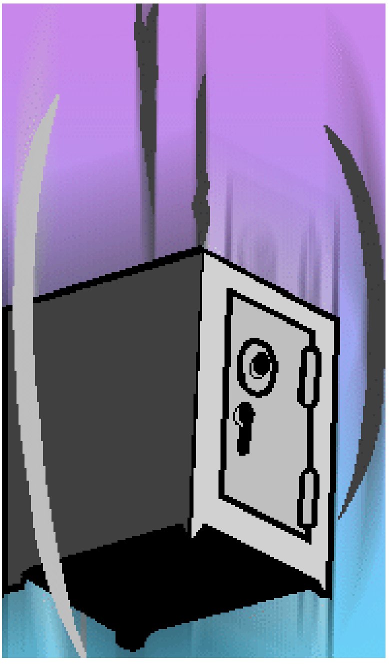
Air mass thunderstorms are most frequent, particularly in summer, in the south central and southeastern states. Thunderstorms associated with frontal systems occur as warm air is lifted aloft in the frontal zone to form the cumulonimbus cloud.

Thunderstorms found on the windward sides of mountain ranges are the result of orographic lifting – warm air forced up and over a mountain. This type of thunderstorm generally occurs during the summer months.

The currents in a growing cumulus cloud in the early stages begin with vertical currents or updrafts that extend from near surface to the top of the cloud. The mature stage is reached when down drafts develop and precipitation falls from the cloud. The cloud is then a full fledged thunderstorm, and all hazards such as turbulence and lightning reach their greatest intensity.



Raindrops that repeatedly ride strong vertical currents to the top of the cloud can end up as hailstones. Once a droplet has frozen, others attach themselves to it as it rises and falls in the cloud. It drops to the earth as a hailstone when it becomes too heavy for the updrafts to support. Hailstones



vary in size, depending upon the growth of the cloud where it originated. The smallest hailstone is about the size of a pea. The grand champion hailstone that bombed Potter, Nebraska, on July 6, 1928, weighed 1.58 pounds and measured 5.2 inches in diameter.

Lightning usually does not occur in a thunderstorm until its top spreads laterally into an ice crystal anvil-shaped cloud. At this stage, falling ice particles cool and literally "seed" the cloud while creating strong down drafts. The vigorous upward and downward motion of the currents and the friction created by the collision and jostling of various sized raindrops appears to be the mechanism that alters the normal electrical field of the atmosphere.

The friction created by the movement of various sized rain drops and ice crystals results in the larger droplets being negatively charged while the smaller are positively charged. The location of electrical centers within a thunderstorm is determined by the weight and size of the droplets and the strength of the vertical currents.

Lightning is dangerous to both man and the environment. It is the greatest single cause of forest fires in the western United States. It is estimated

that lightning ignites more than 7,500 forest fires annually, with the greatest number of occurrences in the Rocky Mountains. Humans take hits too. Nearly 200 people die annually from lightning strikes. The greatest numbers of casualties are people engaged in outdoor recreation or work.

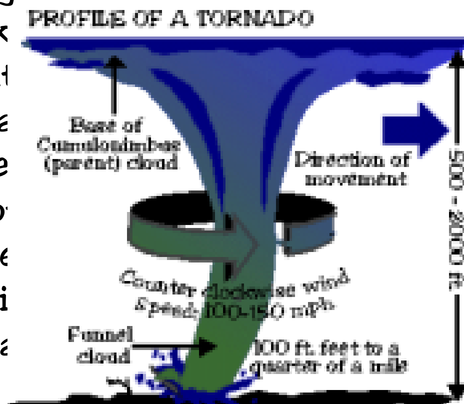
The sudden heating and expansion of air along the lightning channel immediately after a lightning stroke, followed by the instantaneous cooling of the air, creates the major vibration known as thunder. It is sharpest when there are very abrupt changes in the electrical field. Thunder is seldom heard at distances greater than 15 miles from the point of discharge. Since the speeds of light and sound are known, distance from the lightning stroke can be estimated by counting the seconds between seeing the flash and hearing the thunder. Five seconds is equal to about one mile.

TORNADOES

A tornado is a localized, but extremely destructive whirlwind that descends from the base of a thunderstorm. The twisting vortex extends earthward as a projecting funnel of powerful winds that sucks up roofs, trees, farmland and forests. Unlike the gentle transport of Dorothy in the "Wizard of Oz," these nasty storms can transform a residential area or main business street into a heap of rubble in just seconds.

Tornadoes are not just a phenomenon in this country; they occur on all continents but are most common in the United States and Australia. Every state in the Union, including Hawaii and Alaska, has been touched by a tornado. Over a thousand tornadoes are observed annually in this country, but not all touch the surface or do significant damage. The greatest activity occurs in April, May, and June, but no month is free of them. Action is at a minimum in December and January. The most favorable areas for tornado activity include Texas, Kansas, Oklahoma, and Missouri.

Tornadoes vary greatly in size, track and force, making it difficult to provide a representative profile. More often than not the life span is limited to minutes, during which they travel along a path that can vary in length from a few to many miles. Because of the variation in size and intensity the National Weather Service established 3 categories to identify them. The mini-tornado, with winds of less than 100 mph and lasts only a few minutes. The medium tornado has winds from 100-150 mph and lasts up to 20 minutes. The deadliest is the maxi-tornado with winds greater than 150 mph, lasts up to 3 hours, and can cause damage along a path 1.5 miles wide and 200 miles long.



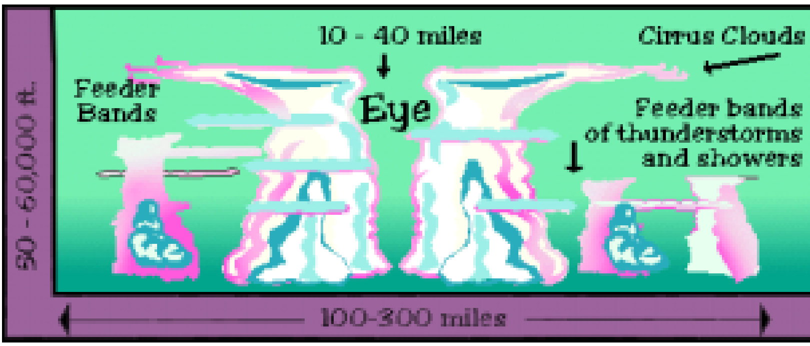
The intensity of a tornado depends on the intensity of the parent cloud.

The tornado funnel is a portion of the parent cumulonimbus cloud that extends groundward to the surface. Initially it contains only condensed water vapor but as the funnel touches the ground, it draws a great amount of dirt and debris upwards darkening the entire column. The funnel may appear as a thin rope or a gigantic elephant trunk dangling from the sky. The angle of the funnel between the cloud base and the surface ranges from vertical to diagonal. In some extreme cases, winds within the funnel have reached an estimated 250 mph. Atmospheric pressure within the funnel is extremely low. It is the combination of extreme pressure differences and intense winds that causes such great damage.

There is another type of whirlwind that is frequently observed, but without the devastating consequences of the tornado. Dust devils develop wherever intense surface heating occurs over a relatively small area. They can be seen over a dusty field in the summer or swirling leaves in little counter-clockwise circles on an autumn day. They are not associated with any cloud form. Like the tornado, however, dust devils have low atmospheric pressure at the center. They can vary in height from a few feet to as much as several hundred feet, while the counterclockwise winds in the vortex range from 10 to 50 mph. These mini low pressure systems are guided by the prevailing winds and topography of the area. A dust devil can spin as long as an hour under certain conditions before dissipating.

HURRICANES

The most destructive and extensive of all weather phenomena is the hurricane. Winds in a tornado can momentarily exceed those of a hurricane, but the life cycle of a tornado is primarily measured in



minutes. The life cycle of a hurricane, however, is measured in weeks and its extraordinary size exceeds any other meteorological phenomenon.

Each part of the world has its own name for the fully mature tropical cyclone. They are hurricanes in the Atlantic, Caribbean, Gulf of Mexico, and Eastern and Central Pacific Ocean. In the Western Pacific they are known as typhoons, and simply as cyclones in the Indian Ocean. They are a Willy-Willy in Australia; a baguio in the Philippines, a traino in Haiti, and a cordonazo in Mexico.

A hurricane originates as a tropical cyclone over low latitude ocean areas. Several phases of development take place before a tropical cyclone develops into a hurricane. Growth is determined by the strength of the sustained wind: The tropical depression has winds less than 36 mph; winds of a tropical storm range from 36 and 74 mph. The hurricane has sustained winds greater than 74 mph.

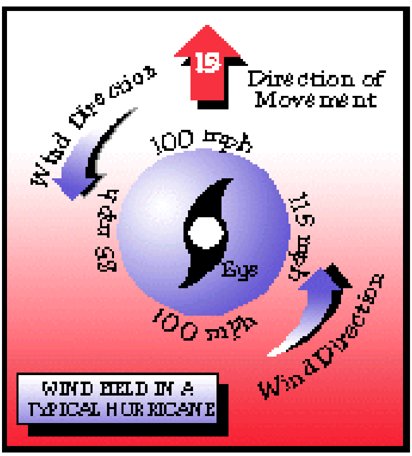
TROPICAL CYCLONES

DEPRESSION	36 mph
TROPICAL STORM	36 to 74 mph
HURRICANE	more than 74 mph

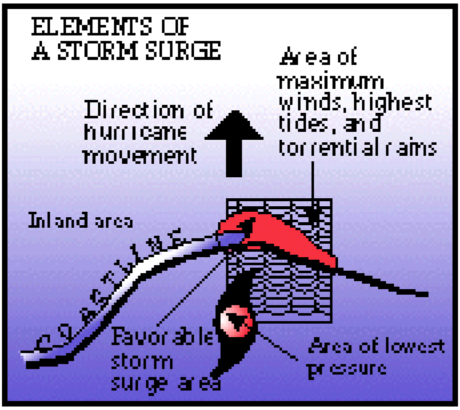
North Atlantic tropical cyclones usually move initially in a westward direction with the prevailing easterly trade winds. They gradually drift northward as they move into higher latitudes with speeds from 10 to 15 mph. As the storms recurve toward a more northerly direction, the speed of movement increases significantly as the system comes under the influence of the westerly winds aloft.

The near cloudless center of a tropical cyclone, called the eye, is peculiarly unique. It normally develops during the tropical storm stage and is usually well pronounced in the hurricane stage. It is characterized by the lowest pressure, confused sea conditions, light and variable winds, and temperatures higher than outside the eye. They are not necessarily circular. Some eyes are elongated in shape, usually in the direction of movement. The average diameter is fifteen miles, but can range from two to forty miles although eyes of 70 to 90 miles in diameter have been reported. The eye is surrounded by cumulonimbus wall clouds that extend to altitudes of 50,000 to 60,000 feet.

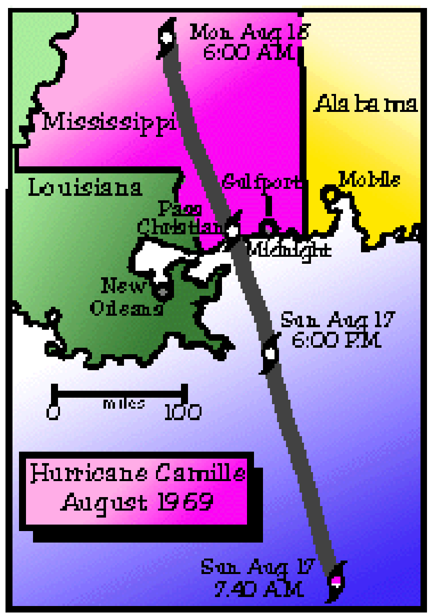
Winds in a hurricane are not uniform, varying from quadrant to quadrant. For example, a hurricane with 100 mph winds, moving north at 15 mph, will have 115 mph winds in the right front sector, but only 85 mph winds in the left front. This is due to the forward speed either adding to, or taking from, the total wind force.



The greatest hurricane damage occurs just to the right of the storm track. The combination of sustained strong winds reinforced by the movement of the storm, high tides, run off from torrential rains, and reduced atmospheric pressure can result in a "storm surge." The ensuing wall of water can reduce coastal areas to shambles.



On August 18, 1969, Hurricane Camille made landfall on the coast of Mississippi. The storm was one of the most intense ever to strike the Gulf Coast. Camille was accompanied by winds gusting to 190 mph and a storm surge estimated to be 20 to 26 feet. The toll in Mississippi and Louisiana was 135 people killed and 42 missing. By the time the remains of Camille dissipated in southwestern Virginia, over 300 people were dead and approximately $1.4 billion in damage was inflicted.



CLIMATOLOGY

Climate represents average weather of an area over a period of many years. This is in contrast to weather, which is the day to day changes in the atmosphere. Climatology is the data base of climate and includes most meteorological elements such as daily maximum and minimum temperatures, wind, cloud coverage, and precipitation.

Statistics for climatological tables are based on the most recent 30 years of observations from a weather station. The usual format for compiling climatological data is by monthly averages. The information is useful for planning future activities such as construction, agriculture, and even picnics.

Climatology offers some interesting insights into the weather of an area. Weather people are similar to baseball fans in that they delight in using statistics when discussing weather. Following are a few historic low temperatures (in degrees F.) for U.S. cities: San Francisco recorded 20° in 1932; Chicago -27° in 1985 and Central Park in New York City experienced -15° in 1934.

Climatological Table

Average Daily Maximum and Minimum Temperatures for Selected Months and Cities

City	Jan	Mar	May	Jul	Sep	Nov
Boston, MA	36/22	45/32	67/50	81/65	72/57	52/39
Chicago, IL	31/15	45/27	70/47	83/61	75/52	48/31
Gulfport, MS	61/42	70/51	84/66	91/73	88/69	70/49
Honolulu, HI	79/65	80/66	84/70	87/73	87/73	83/70
Jacksonville, FL	65/44	72/50	85/64	90/72	86/70	71/51
Key West, FL	76/66	79/70	85/76	89/80	88/79	80/71
Memphis, TN	49/32	61/41	81/61	92/72	84/63	62/40
Minneapolis, MN	21/03	37/20	68/46	82/61	71/49	41/24
New Orleans, LA	62/44	70/51	85/65	90/73	87/70	70/50
New York, NY	38/26	47/34	70/54	84/69	75/61	53/41
Norfolk, VA	49/32	57/39	76/57	87/70	80/64	60/43
Pensacola, FL	61/43	70/51	84/66	90/74	86/70	70/49
Portland, ME	31/12	41/23	64/42	79/57	70/47	47/30
San Diego, CA	65/46	66/50	69/57	75/64	77/63	70/52
San Francisco, CA	55/41	61/45	67/50	71/54	74/54	63/47
Seattle, WA	43/33	52/37	64/46	75/54	69/50	50/39
Washington, DC	41/23	53/31	74/51	86/64	79/55	56/34

Thunderstorm Safety Precautions

- Stay indoors until the storm is over.

- Avoid hilltops, open spaces, wire fences and metal sheds.

- Get out of the water and small boats.

- Don't handle metal fishing rods or golf clubs. (Spiked golf shoes are dangerous lightning conductors.)

- Stay away from open windows and doors, fireplaces, metal pipes and sinks.

- Don't plug-in or use electrical appliances like hair dryers, razors or electric tooth brushes.

- Don't use the telephone – lightning could strike nearby telephone lines.

- Stay in your automobile if traveling. They provide excellent lightning protection.

NAVAL METEOROLOGY AND
OCEANOGRAPHY COMMAND

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